

ARM/GCSS/SPARC TWP-ICE CRM Study

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Christopher Williams • NOAA Earth System Research Laboratory

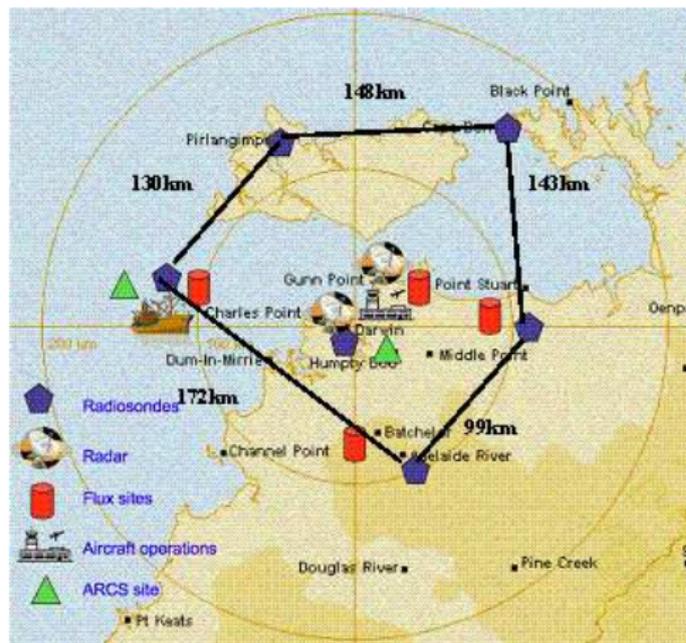
Sally McFarlane, Jim Mather and Chuck Long • PNNL

Dave Turner • University of Wisconsin

Guosheng Liu • Florida State University

Cloud Modeling Working Group Meeting • 20 November 2008

Experiment domain



Source: *Shaocheng Xie, LLNL*

Experiment goals

- make detailed measurements of cirrus microphysics and their relationship to storm structure and intensity
- characterize and document evolution
 - microphysical properties
 - large-scale environment
 - convective boundary layer
 - dynamical and radiative impacts
- verify remote-sensing data
- provide data for forcing models

Model intercomparison studies

- interlocking studies - Jon Petch
 - Global Energy and Water cycle EXperiment (GEWEX) Cloud System Study (GCSS) - Precipitating Cloud Systems
 - Stratospheric Processes And their Role in Climate (SPARC)
- cloud-resolving models (CRMs) - Ann Fridlind
 - 16 days
- single-column models (SCMs) - Christian Jakob/Laura Davies
 - 26 days
- limited-area models (LAMs) - Maria Russo
 - several days

CRM study goals

- evaluate models
 - simulations and data agree?
 - data sufficient to evaluate models?
 - additional data needed?
 - methodology sufficient?
- quantify convective transport to the tropopause
 - CRM predictions consistent with measurements and theory?
 - temporal and spatial characteristics of vertical mass transport?
 - influence on water vapor near the tropopause?
 - primary uncertainties in simulations and data?

CRM study participants

- Ann Fridlind, NASA GISS
- Jon Petch, UK MetOffice
- Wojtek Grabowski, NCAR
- Yi Wang, PNNL
- Xiaohong Liu, PNNL
- Charles Seman, GFDL
- Annica Ekman, Stockholm University
- Axel Seifert, German Weather Service
- Virginie Marécal, University of Orléans/CNRS
- Jean-Pierre Chaboureau, University of Toulouse/CNRS

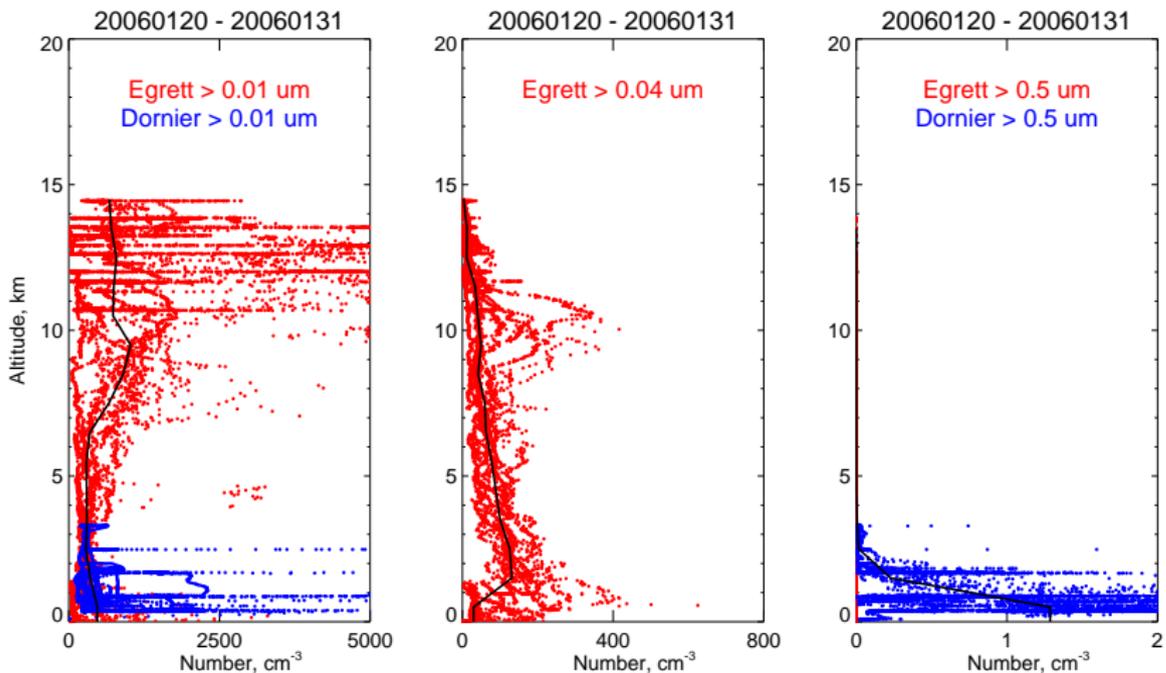
GISS simulations

- general
 - horizontal domain size = 176 × 176 km (or 72 × 72 km)
 - periodic boundary conditions (idealized marine)
 - fixed SST = 29°C
 - interactive surface fluxes
 - large-scale forcings from variational analysis
 - baseline and sensitivity test
 - nudge Θ , water vapor at $Z > 13\text{--}15$ km, $\tau = 6$ h
 - nudge at $Z > 0.5\text{--}1$ km, $\tau = 6$ h
- example
 - vertical domain size = 24 km
 - horizontal grid = 1 km (or 125 m)
 - vertical grid = 100–250 m (or 62.5–125 m)
 - bulk microphysics (Grabowski, 1999)
= cloud liquid, rain, fluffy ice, dense ice
 - 2-stream radiative transfer, 44 bands, size-resolved Mie

Aerosol specification

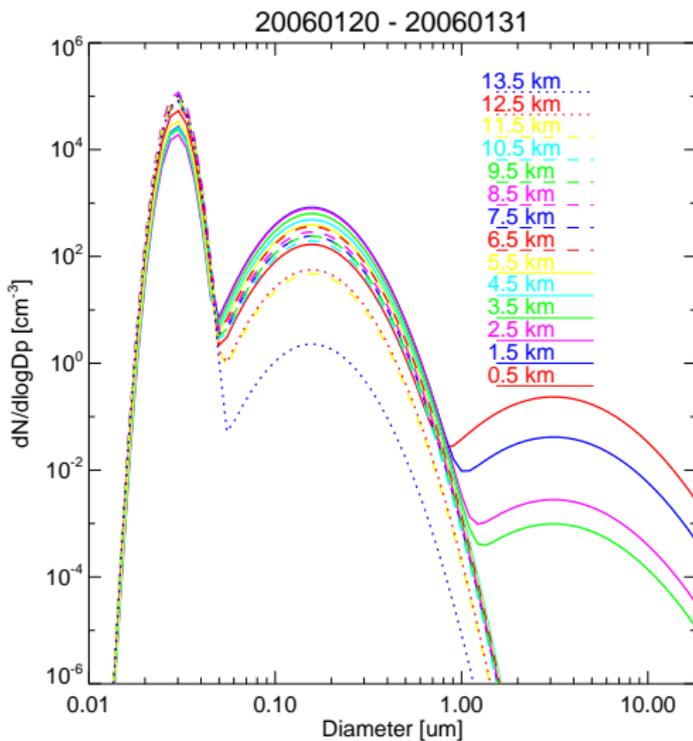
- Aerosol and Chemical Transport in tropical conVEction (ACTIVE)
 - funded by the UK Natural Environment Research Council
 - <http://cloudbase.phy.umist.ac.uk/field/active>
- bulk mass composition [*Allen et al., 2008*]
 - 80% ammonium sulfate
 - 20% organics
- number size distribution profiles
 - three lognormal modes [*Allen et al., 2008*]
 - diameter = 0.03, 0.18, 4.4 microns
 - standard deviation = 1.12, 1.45, 1.8
 - profiles of number concentration in each mode
 - <http://www.giss.nasa.gov/~fridlind/twp-ice/setup>
- no ice nucleus measurements

Number concentration profiles



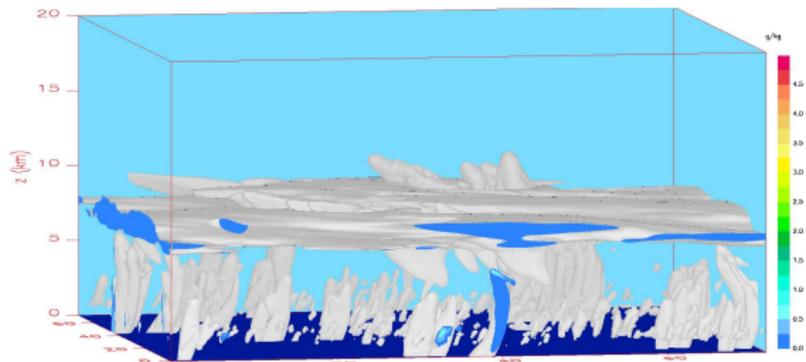
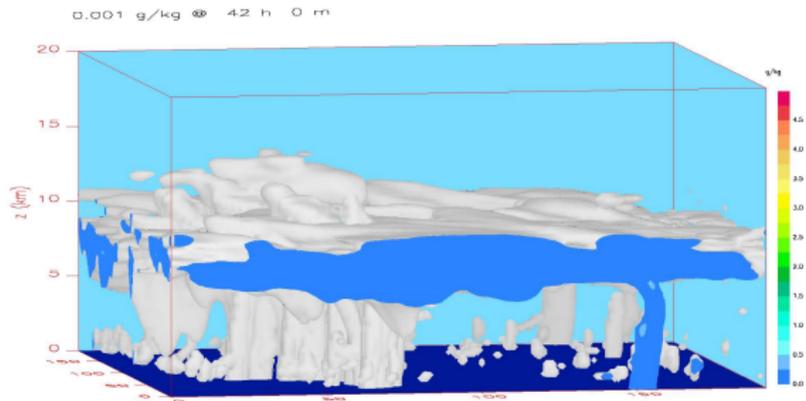
Data: *Martin Gallagher, Paul Williams, Andrew Heymsfield, Aaron Bansemer*

Number size distribution profiles

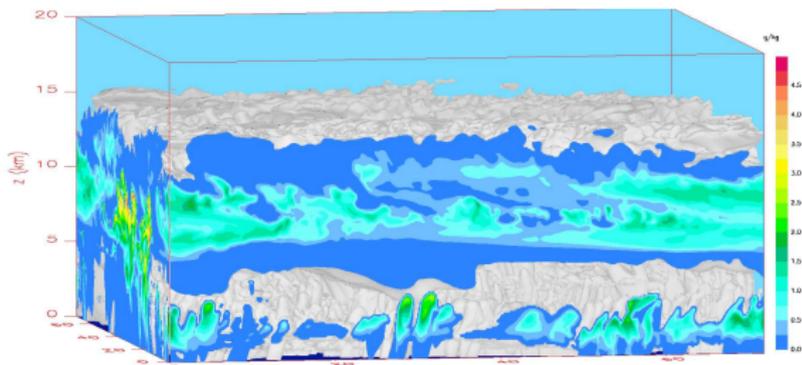
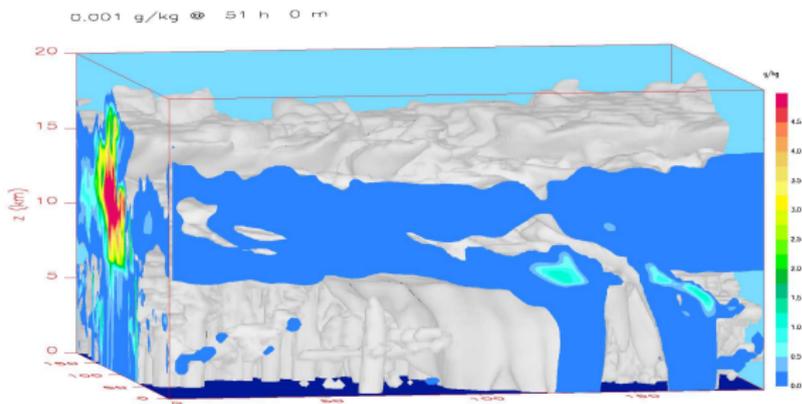


Data: *Martin Gallagher, Paul Williams, Grant Allen*

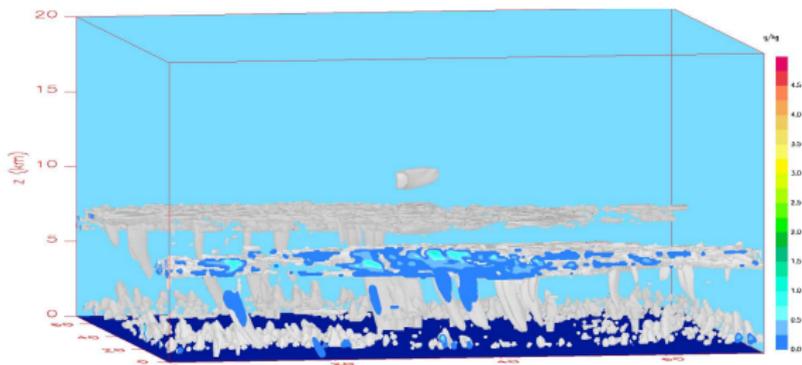
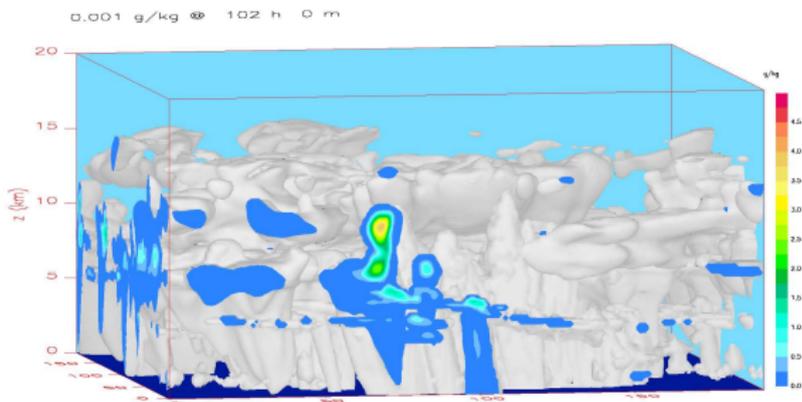
Cloud isosurfaces



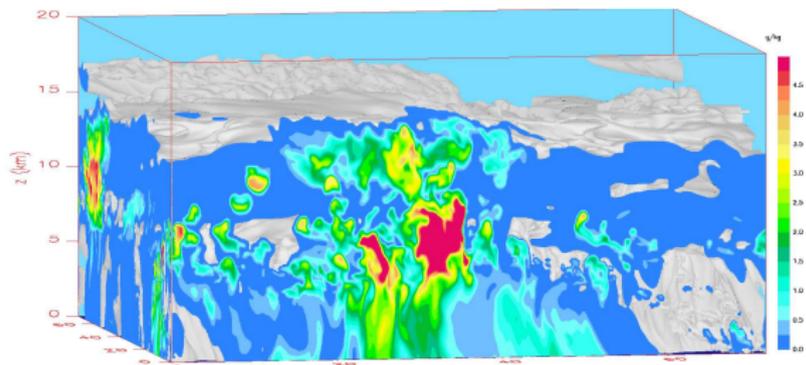
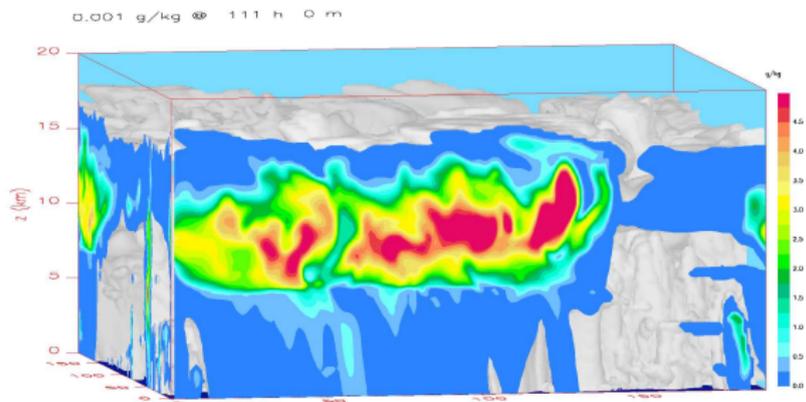
Cloud isosurfaces



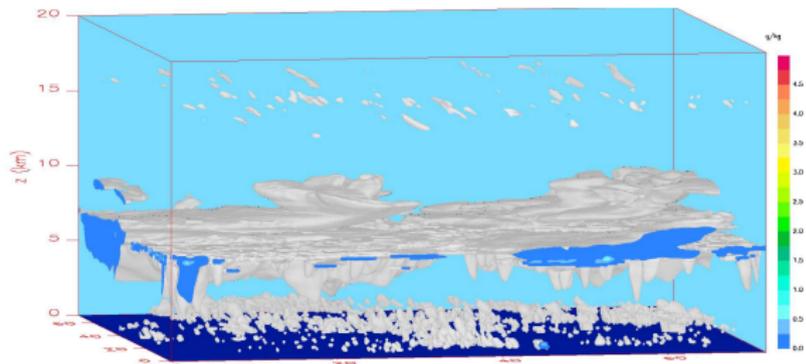
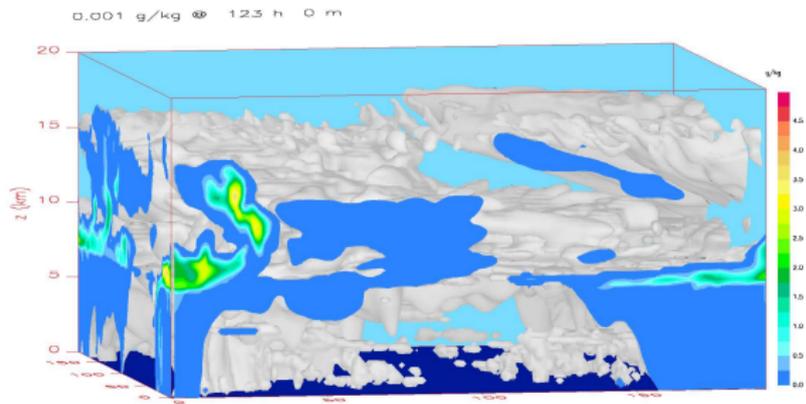
Cloud isosurfaces



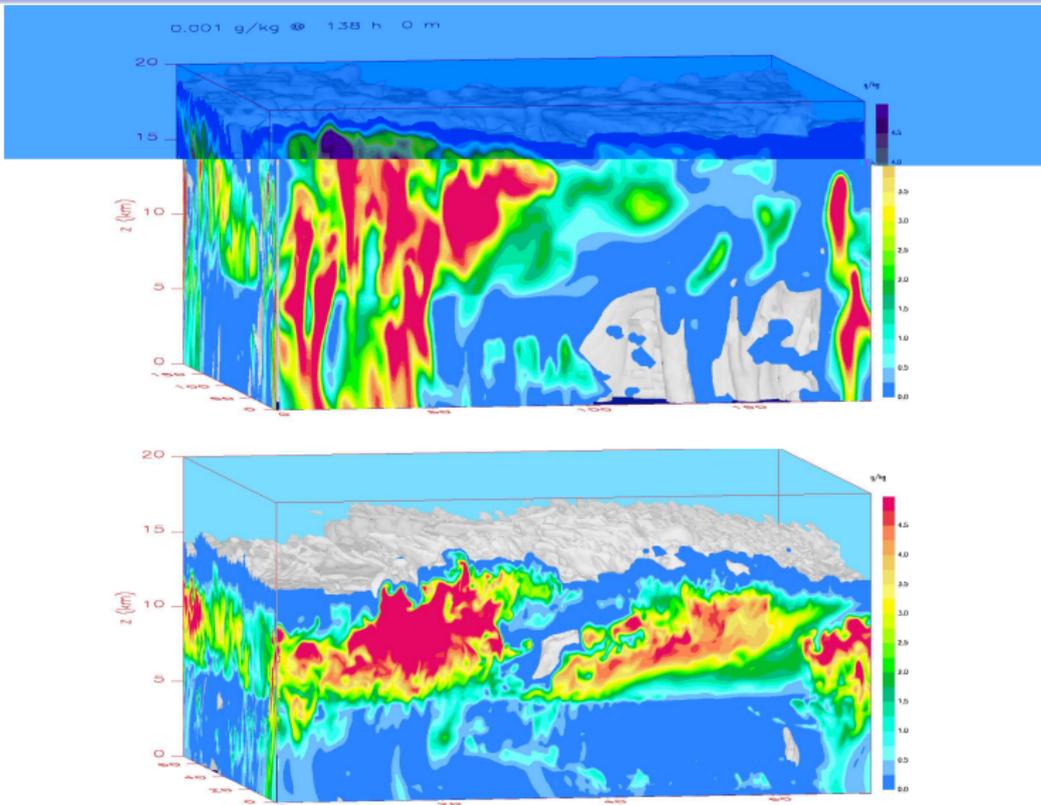
Cloud isosurfaces



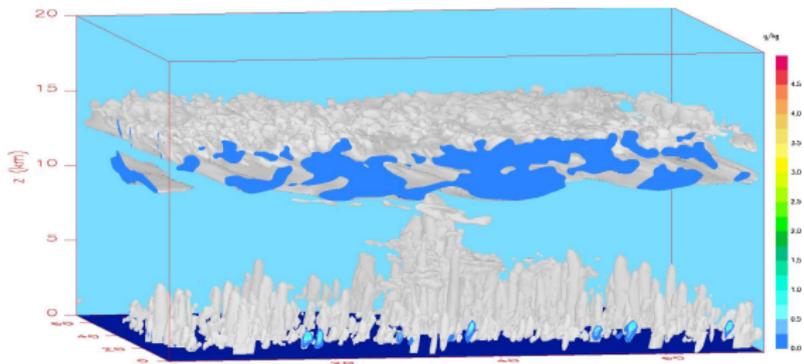
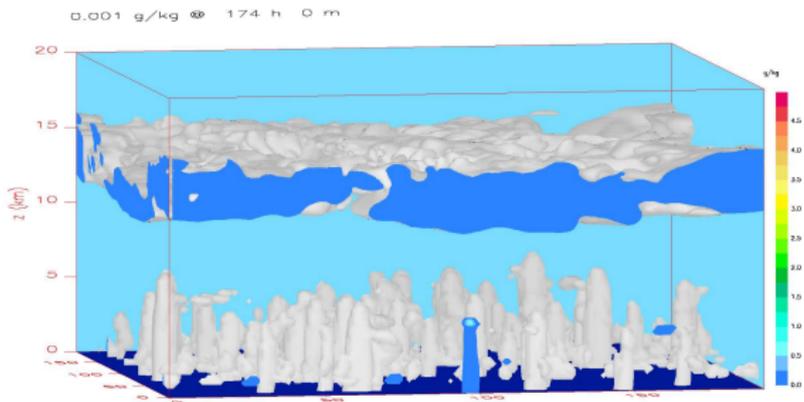
Cloud isosurfaces



Cloud isosurfaces



Cloud isosurfaces



Data constraints on model performance

Physical Variable

Precipitation rate

Liquid water content

Liquid water path

Ice water content

Ice water path

Total condensate content

Total condensate path

Water vapor

Cloud base height

Cloud top height

Cloud fraction

Radar reflectivity

Doppler velocity

Data Set (PI)

C-pol (May), disdrometer and buckets (Williams)

disdrometer, TCPRHP (McFarlane/Mather)

MWR (Turner), TCPRHP

TCPRHP, 3D-Ice (Liu)

VISST (Minnis), TCPRHP, 3D-Ice

CSI (McFarquhar)

MODIS

sondes (Jakob/Hume), in situ (Whiteway, Hacker)

ARSCL, VISST (Minnis)

ARSCL, VISST

TSI (Morris), SFA (Long), MODIS

C-pol, S-band (Williams), disdrometer

S-band, disdrometer

Data constraints on model performance

Physical Variable

Particle number

Particle area

Particle size

Cloud optical depth

SFC broadband flux

TOA broadband flux

Column absorption

Broadband flux profile

Broadband heating rate profile

Latent heating rate profile

Surface SH and LH fluxes

Data Set (PI)

CIP (McFarquhar)

CIP (McFarquhar)

C-pol, **disdrometer**, TCPRHP, VISST, MODIS

TCPRHP, VISST, MODIS

TCPRHP, SKYRAD/GNDRAD

TCPRHP, VISST

TCPRHP

aircraft (McCoy), TCPRHP

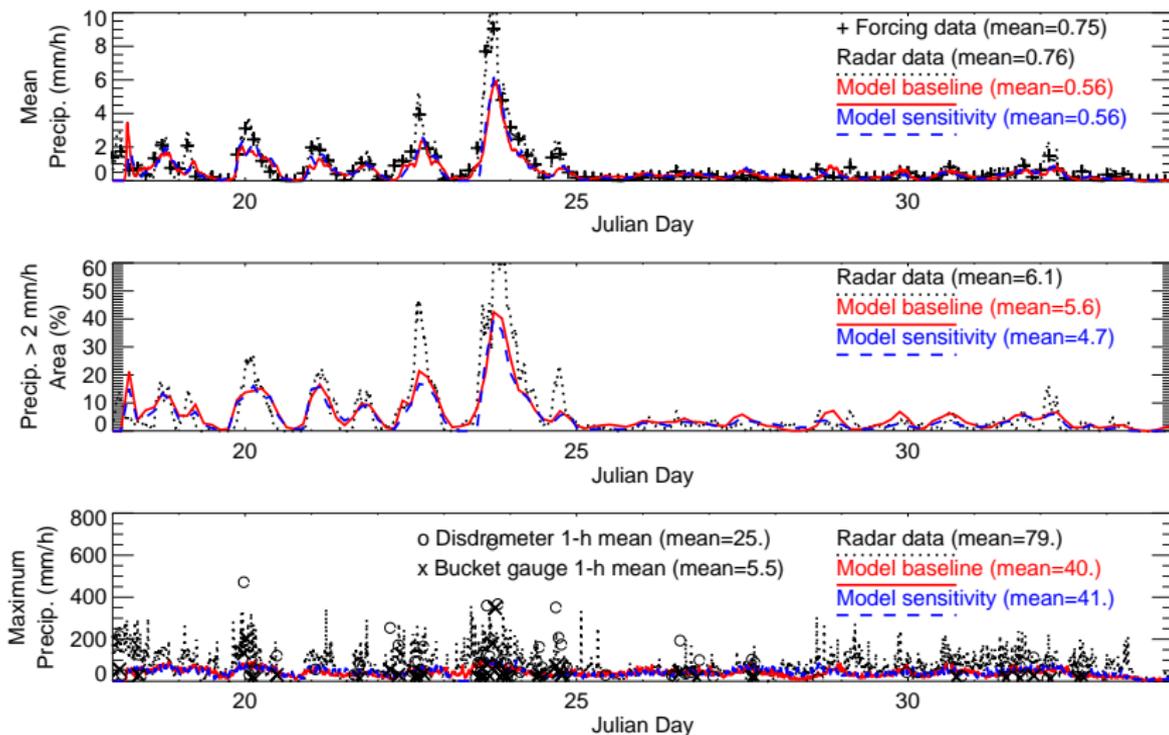
TCPRHP

C-pol (Schumacher)

eddy-correlation (Beringer)

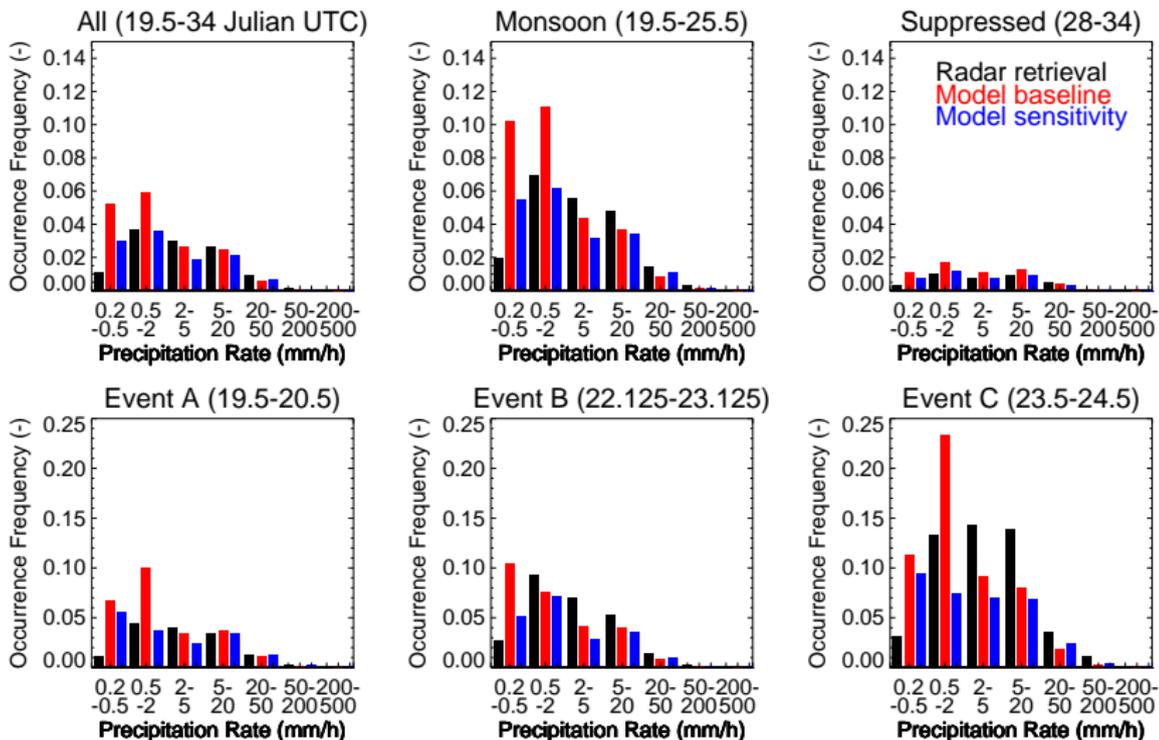
<http://www.giss.nasa.gov/~fridlind/twp-ice/data>

Precipitation rate



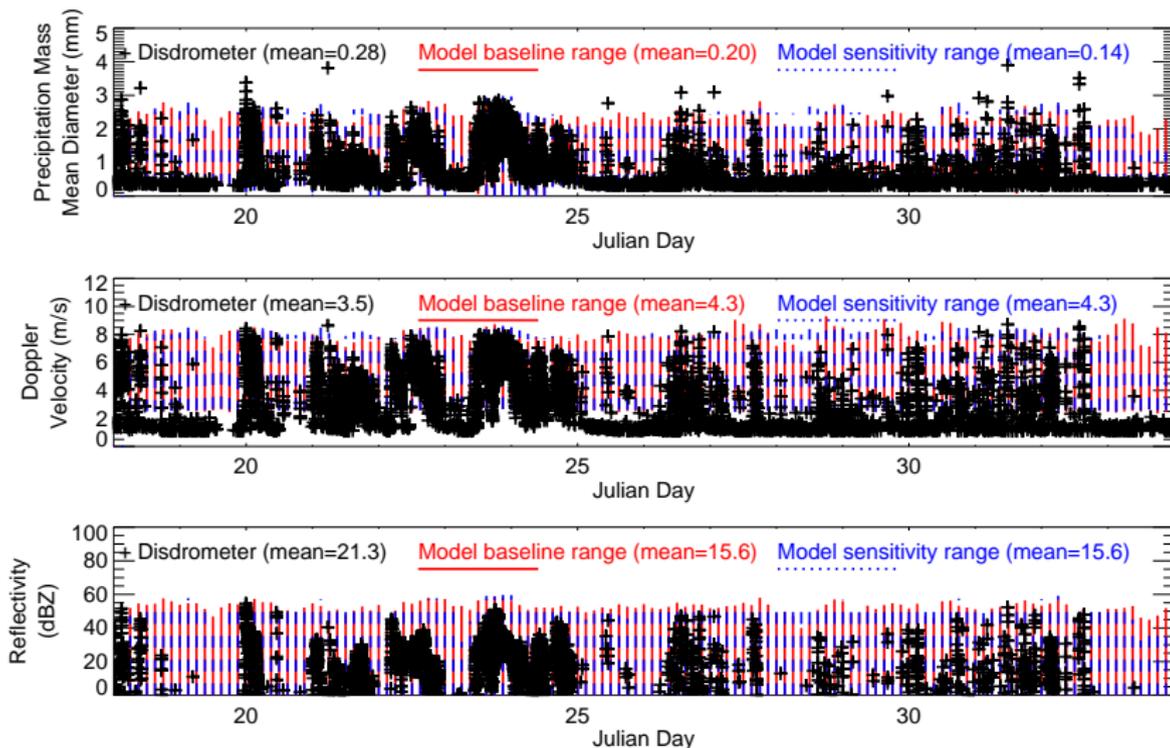
Data: *Shaocheng Xie, Peter May, Christopher Williams*

Precipitation rate



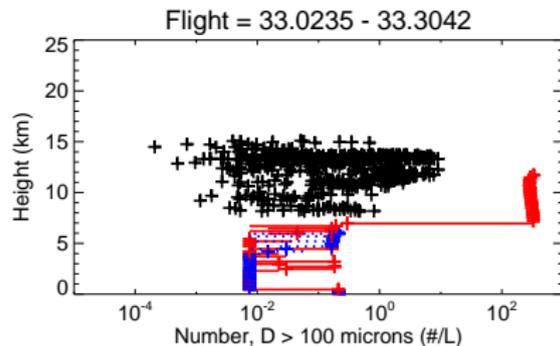
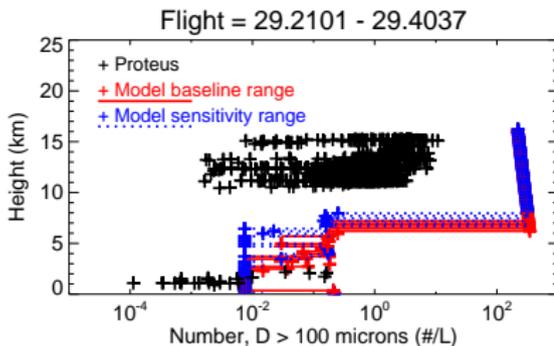
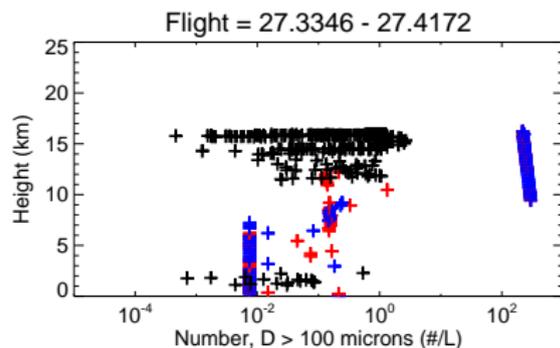
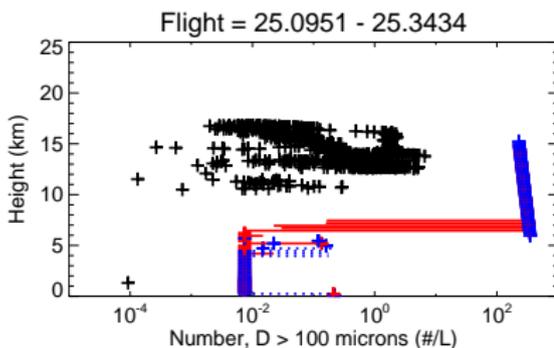
Data: *Peter May*

Precipitation particle size



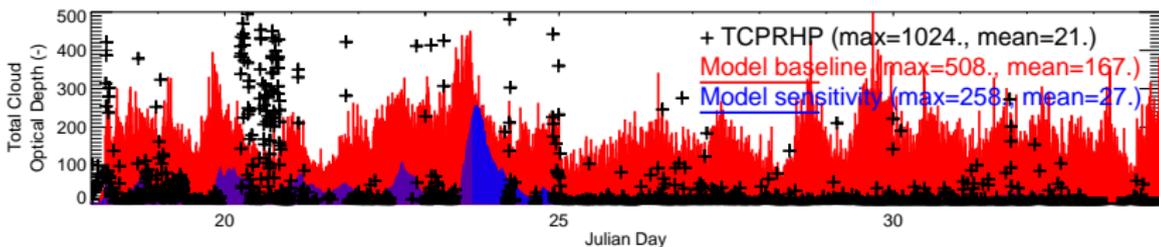
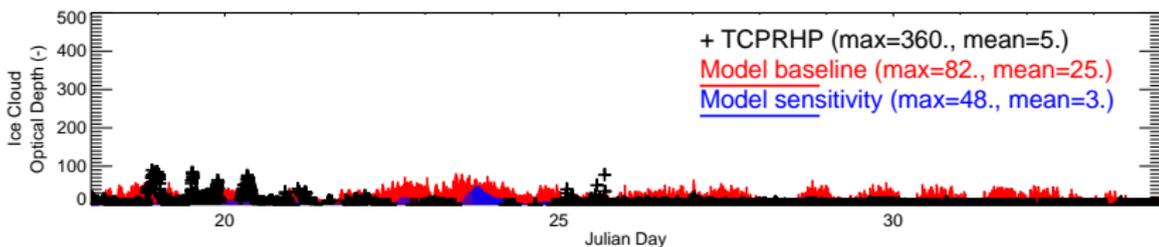
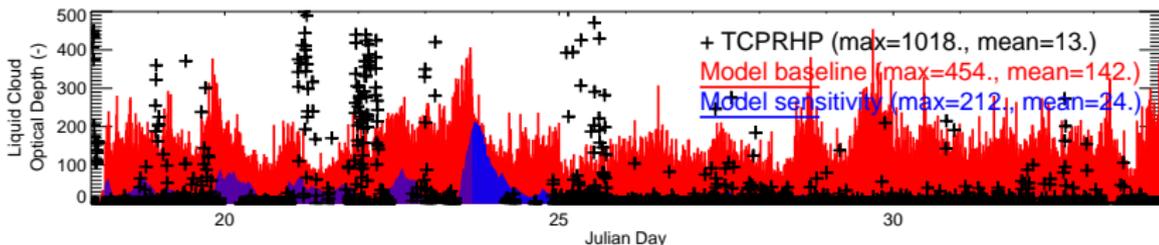
Data: *Christopher Williams*

Number concentration, $D > 100 \mu\text{m}$



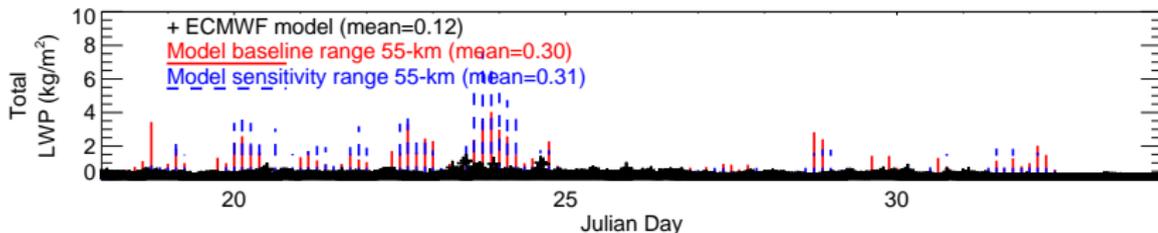
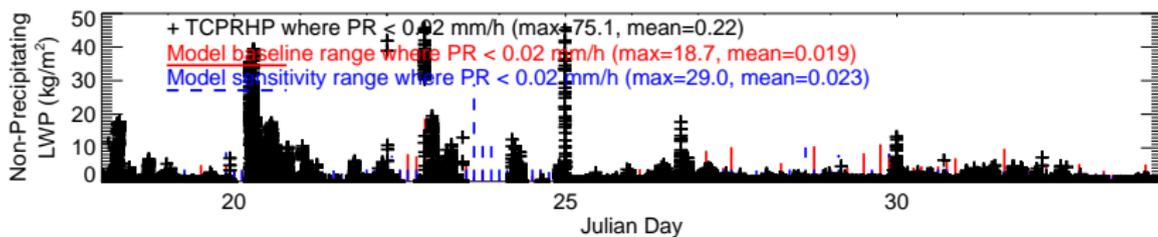
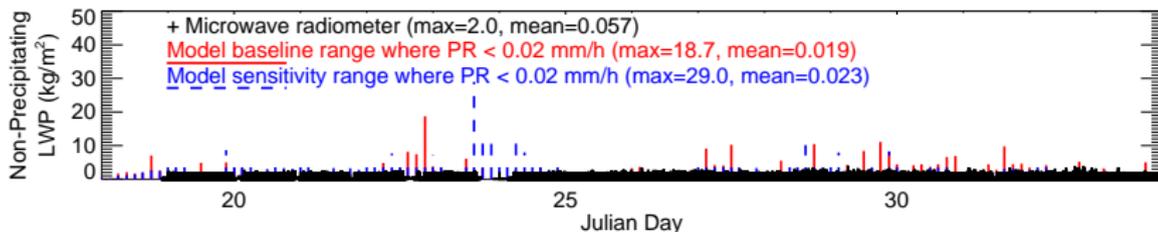
Data: *Greg McFarquhar*

Cloud optical depth



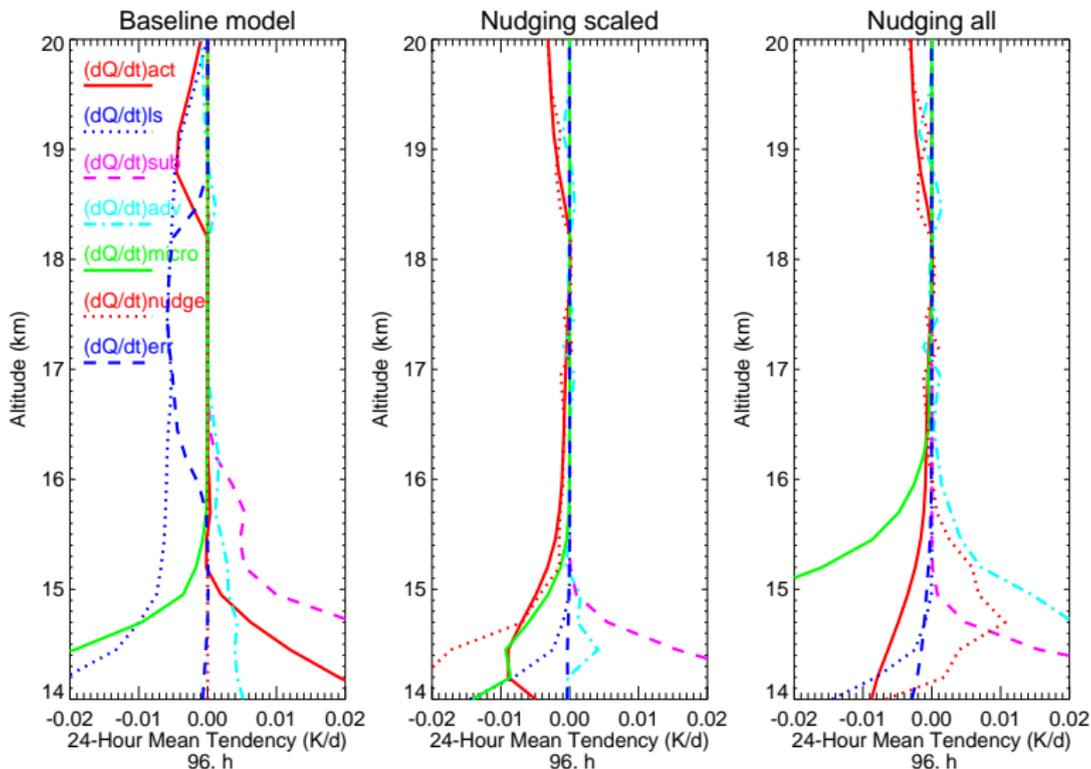
Data: Sally McFarlane/Jim Mather

Liquid water path



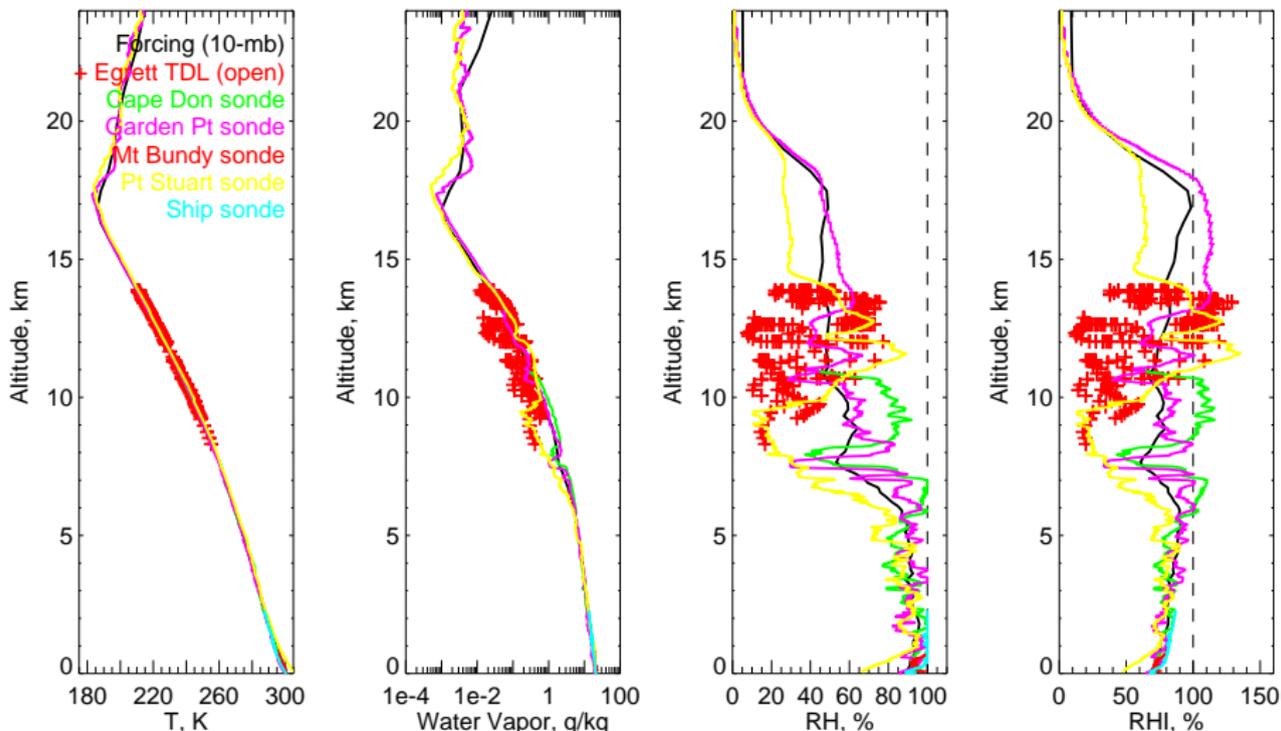
Data: *Dave Turner, Sally McFarlane/Jim Mather, ECMWF*

Moisture budget



Relative humidity data

1/22 9 UTC



Source: *Shaocheng Xie, Christian Jakob, Tim Hume, Jim Whiteway, Clive Cook, Grant Allen*

Summary

- CRM case specification
 - idealized marine
 - 16 days
 - participants welcomed
- first goal: closure experiment
 - <http://science.arm.gov/wg/cpm/scm/scmic6> (Table 1)
 - <http://www.giss.nasa.gov/~fridlind/twp-ice/data> (images)
 - do you have any comments?
 - requested diagnostics can still be changed
- second goal: convective transport (water vapor)
 - influence on water vapor near the tropopause?
 - primary uncertainties in simulations and data?
 - tracer analysis